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Technical Report ARWEC-TR-98006

**DEMILITARIZATION PLAN FOR NON SELF-DESTRUCT
AND SELF-DESTRUCT ANTIPERSONNEL LAND MINES**

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19980924 142

August 1998



US ARMY
TANK AUTOMOTIVE AND
ARMAMENTS COMMAND
ARMAMENT RDE CENTER

U.S. ARMY ARMAMENT RESEARCH, DEVELOPMENT AND
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REPORT DOCUMENTATION PAGEForm Approved
OMB No. 0704-0188

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1. AGENCY USE ONLY (Leave Blank)

2. REPORT DATE
August 19983. REPORT TYPE AND DATES COVERED
Final4. TITLE AND SUBTITLE
DEMILITARIZATION PLAN FOR NON SELF-DESTRUCT AND
SELF-DESTRUCT ANTIPERSONNEL LAND MINES

5. FUNDING NUMBERS

6. AUTHOR(S)

Andrew Lute and Nicholas Scors

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

ARDEC, WECAC
Energetics Systems Process Division (AMSTA-AR-WEA)
Picatinny Arsenal, NJ 07806-500010. PERFORMING ORGANIZATION
REPORT NUMBER

10. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

ARDEC, WECAC
Information Research Center (AMSTA-AR-WEL-T)
Picatinny Arsenal, NJ 07806-500010. SPONSORING/MONITORING
AGENCY REPORT NUMBERTechnical Report
ARWEC-TR-98006

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT

The United States goal is to have all non self-destruct land mines demilitarized by 31 December 1999. To support this goal, this report provides recommendations for demilitarizing these mines as well as self-destructing land mines. Although the use of open burning/open detonation (OB/OD) is the primary method for destroying obsolete munitions because of its simplicity and low cost, increasing environmental regulations are expected to severely limit, if not eliminate the use of OB/OD in the near future. For this reason, OB/OD was not considered in this plan as a demilitarization method. The demilitarization methods and technologies that are addressed in this plan have either been developed by the Armament Systems Process Division of the U.S. Army Armament Research, Development and Engineering Center under the direction of the U.S. Army Defense Ammunition Center, or are based on existing methods used for other items. All methods that are presented in this plan allow for the recovery of materials, with the degree of recovery tied to the activities and economics of the demilitarization method.

14. SUBJECT TERMS

Demilitarization Munitions Cryofracture Land mines

15. NUMBER OF PAGES

51

16. PRICE CODE

17. SECURITY CLASSIFICATION
OF REPORT

UNCLASSIFIED

18. SECURITY CLASSIFICATION
OF THIS PAGE

UNCLASSIFIED

19. SECURITY CLASSIFICATION
OF ABSTRACT

UNCLASSIFIED

20. LIMITATION OF ABSTRACT

SAR

CONTENTS

	Page
Introduction	1
Methodology of Study	1
M16 Series Antipersonnel Land Mines	2
Item Description	1
Demilitarization Methods	3
Cryofracture without Explosive Recovery	3
Autoclave/Melt-out with Explosive Recovery	6
Material Recovery	8
Cryofracture with Explosive Recovery	8
Conclusion	10
M26 Antipersonnel Land Mine	10
Item Description	10
Demilitarization Methods	11
Cryofracture	11
Explosive Recovery Methods	13
Conclusion	13
M14 Antipersonnel Land Mine	13
Item Description	13
Demilitarization Methods	14
Cryofracture	14
Explosive Recovery	16
Conclusion	16
Family of Scatterable Antipersonnel Mines (FASCAM)	16
Item Description	16
General	17
Item Design	17
Functioning	19
Demil Procedure	20
Disassembly Demil Alternative	20
Explosive Recovery	22
Cryofracture Alternative	22
Economic Evaluation	23
Conclusion	25
Conclusions	25

CONTENTS (cont'd)

	Page
Recommendations	26
References	27
Appendices	
A M47 He Antipersonnel Mine	29
B M131 Ground Dispenser and Mines	35
C M87 Canister Mine	41
Distribution List	47

FIGURES

1	M16 (M16A1 and M16A2) antipersonnel mine	2
2	Cryofracture process flow diagram	4
3	Recovery of TNT via autoclave/melt-out system	6
4	Recovery of TNT via cryofracture	8
5	M26 antipersonnel mine	10
6	M14 nonmetallic antipersonnel mine	14
7	BLU-92/B GATOR mine – exploded view	18

INTRODUCTION

In recent years, the desire to ban the use of antipersonnel land mines has gained momentum throughout the entire world. This has come about through an increased sensitivity of their effect on human life, not only on the battlefield, but also to the civilians in those countries where mines were placed, not detonated, and left behind when the particular conflict ended. Each year, many people are injured, maimed, or killed after stepping on these mines, years after the conflict has ended.

As a result, an international agreement is being pursued to ban the use, stockpiling, production, and transfer of antipersonnel land mines with the United States' goal to have all non self-destructing land mines demilitarized by 31 December 1999.

To support this goal, a plan has been developed which provides recommendations for demilitarizing these mines as well as self-destructing land mines. Although the use of open burning/open detonation (OB/OD) is the primary method for destroying obsolete munitions because of its simplicity and low cost, increasing environmental regulations are expected to severely limit, if not eliminate the use of OB/OD in the near future. For this reason, OB/OD was not considered in this plan as a demilitarization method. The demilitarization methods and technologies that are addressed in this plan have either been developed by the Armament Systems Process Division of the U.S. Army Armament Research, Development and Engineering Center (ARDEC) under the direction of the U.S. Army Defense Ammunition Center (USADAC) or are based on existing methods used for other items. All methods that are presented in this plan allow for the recovery of materials, with the degree of recovery tied to the activities and economics of the demilitarization method.

METHODOLOGY OF STUDY

The effort was initiated with the prioritization of the list of mines in regard to the need to demil. The Industrial Operations Command was consulted and the mines were prioritized in the following order: M16 series, M26, M14, and the Family of Scatterable Mines (FASCAM). The area denial artillery munition (ADAM) and pursuit deterrent munition (PDM) were not included as part of this effort. Because the housing for these mines contains depleted uranium, processes to demilitarize these items are being addressed under a separate effort.

Once the items were prioritized, Depot Maintenance Work Requirements (DMWRs) were reviewed in order to identify the methods currently being used or which have been developed to demilitarize the mines. Depot Maintenance Work Requirements were not available for all items. They were only available for the M16 and M16A1, the M26, and the Volcano and modular pack mine systems (MOPMS) from the FASCAM family. The only demilitarization method addressed in these DMWRs is open detonation, which is the traditional method for disposing of munitions.

Item drawings, item data sheets from Technical Manual 43-0001-36 (apps. 1 to 3) and any other related material that was available was obtained and reviewed in order to become familiar with the items and their components and also to identify any materials that would potentially require any special handling procedures. The Munitions Items Disposition Action System (MIDAS) database was also used and provided the amounts of the different materials in each mine. This information could also be used for the initial characterization of the items to minimize the amount of testing that

would be required to verify the applicability of the recommended demil method with the item being discussed. In addition, this information enabled the plan to determine if there are any hazardous materials in the item. The Defense Reutilization Marketing Office was consulted to obtain current market values for scrap metals and also recent sale prices for energetic materials. Inflation rates were not applied to any dollar figures in this report. This information, along with the information obtained from MIDAS was used to calculate the recycle values for each item.

The listing of Ammunition Peculiar Equipment (APE) from TM 43-001-47 was also reviewed to determine if equipment exists that had previously been developed specifically for disassembly of any of these mines or if there is equipment that may be able to be adapted for use to disassemble these mines.

M16 SERIES ANTIPERSONNEL LAND MINES

Item Description

The M16 (fig. 1) series mines (M16, M16A1 and M16A2) are of the bounding, fragmenting type and are employed primarily in mixed mine fields to protect antitank mines against enemy breaching parties. They can be used by themselves in the preparation of ambushes or in the nuisance mining of areas likely to be occupied by enemy troops.

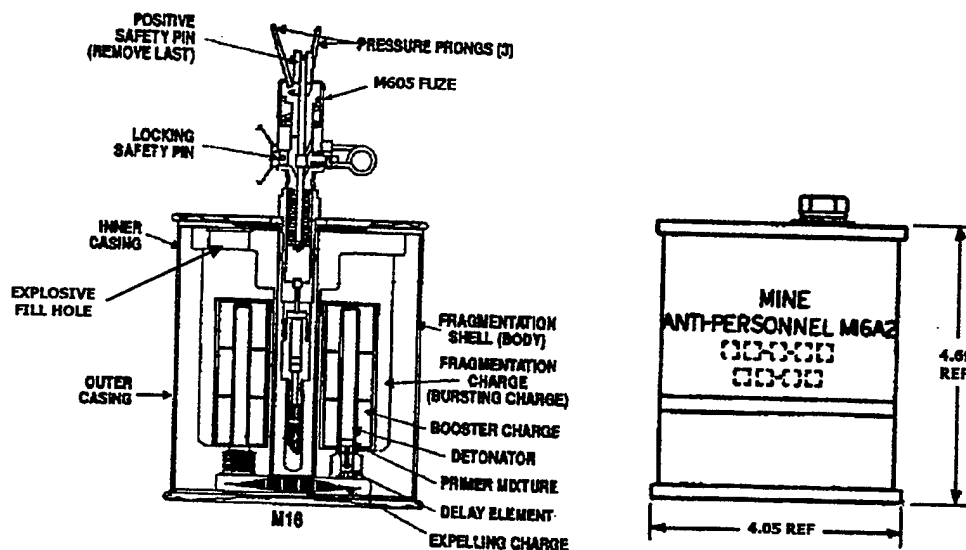


Figure 1
M16 (M16A1 and M16A2) antipersonnel mine

These mines consist of an M605 combination mine fuze; a propelling charge; and a cast iron, fragmenting inner case all contained in a sheet steel outer case. The fuze, which is shipped unassembled to the mine but in the same packaging, screws into the fuze well in the top of the case and extends through the projectile to the bottom of the case where the propelling charge is located. The mine is shipped with a plug screwed into the top of the fuze well cavity to prevent any foreign object from being inserted into the cavity and prematurely setting off the mine.

The principal difference between the M16 and M16A1 models is in the construction of the detonators and boosters. The M16A2 mine is an advanced version of the series and incorporates only one booster detonator and delay instead of two each. This allows greater room for the explosive charge.

Demilitarization Methods

A number of demilitarization technologies currently under development were evaluated for possible use in destruction of the M16 series mines. Technologies such as supercritical water oxidation (SCWO), plasma arc, and cryofracture were reviewed to determine the method that would best accommodate the item from the standpoints of size, energetic components, and economics. Supercritical water oxidation was eliminated from consideration as a destruction method because of the preparation that would need to be performed before a mine could be processed through a SCWO unit. Because the SCWO can only process bulk organic (energetic) materials and not components such as steel, cast iron, plastics, etc., the mine would need to be disassembled and the energetic material removed from the mine before it could be processed through the SCWO system. The remaining metals could be sold as scrap, but would first need to be processed through a furnace to destroy any remaining energetic residue. Considering the number of operations that would need to be performed to use this process and to recover only part of the item components, it is not economically feasible to consider the SCWO for this item.

Plasma arc was eliminated from consideration as a destruction method because there is a question as to whether explosive materials could be processed through the plasma arc system. The test program conducted to date has centered on pyrotechnic items, none of which contain explosive materials. To investigate the use of a plasma arc system as a destruction process for explosive loaded items, a substantial test program would need to be conducted.

Pre-treatment methods of punching/sawing/shearing were considered to be of limited value because of the high cost of the labor, equipment, and treatment required for treating the process waste streams. However, they were considered for non-cryogenic alternative disassembly procedures for the M16 and FASCAM family of mines.

Cryofracture has shown excellent potential for the destruction of the M16 series mines. Although live versions of these mines have not yet been tested (they are currently planned for testing in late 3Q/early 4Q FY 98), the results of inert testing showed excellent accessing of the simulant explosive, providing a high level of confidence that live testing will prove to be successful.

Finally, autoclave/melt-out with explosive recovery was evaluated to determine if explosive recovery of TNT is cost effective. A flow chart detailing the processing steps required was developed. Equipment, labor, and material recovery estimates were developed to determine the total cost of the autoclave/melt-out alternative. This process was repeated for all demil alternatives evaluated.

Cryofracture without Explosive Recovery

Cryofracture (fig. 2) involves placing the mine in a bath of liquid nitrogen for a period of time to embrittle the steel body, which contains the explosive charge. Once it is determined that the mine has been sufficiently cooled, it is then transferred to a hydraulic press. Once in the press, the mine would be crushed to a predetermined height to sufficiently expose the energetic materials in order to ensure that a detonation would not occur when subjecting the mine to a thermal treatment unit.

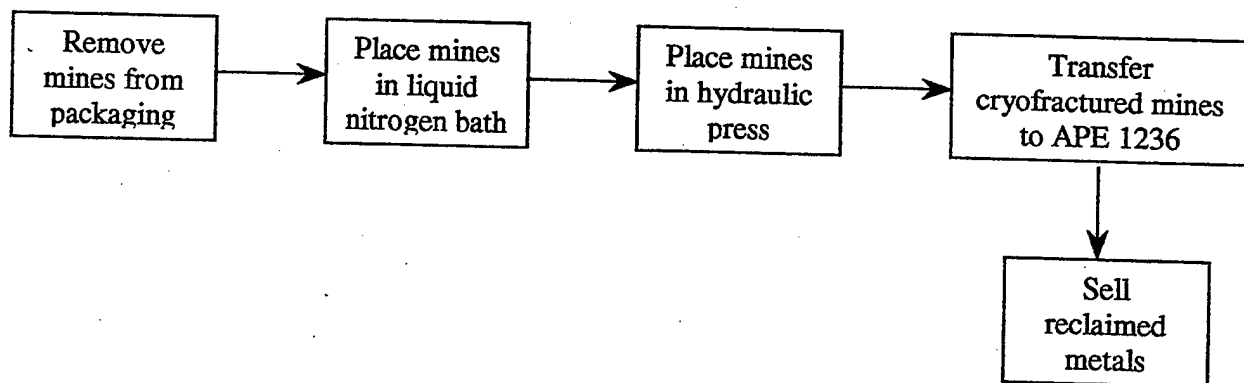


Figure 2
Cryofracture process flow diagram

Explosive sensitivity tests conducted by ARDEC and General Atomics Corporation have shown that there is little or no change in explosive sensitivity at ambient temperature versus cryogenic temperature (-320°F). Past studies on a variety of ammunition items have shown that the cryofracture process is safe when conducted using proper procedures and processing parameters. A partial list of ammunition items tested included 155-mm projectiles (M110 with small bursters and M121A1 with large bursters and supplementary charges); M42, M47, and M77 grenades; M61, M67, M69 hand grenades; 4.2-in. mortar; 8-in. projectiles; and 105-mm cartridges. A test program is recommended for all items to determine specific cryofracture process parameters such as time in cryobath, process crush height, and item orientation.

Because an effort has been initiated to develop a prototype demilitarization facility at McAlester Army Ammunition Plant (AAP), McAlester, Oklahoma, which uses cryofracture technology, the facility development costs were considered to be sunk costs during the development of any economic analyses using this process. The facility development costs include the preparation of all safety documentation, including a hazard analysis of the process. Because the M16 series mines are planned for cryofracture testing in late FY 98, this item has been included on the initial item-processing list for the McAlester facility and therefore will be addressed in the hazard analysis. (Note: If/when the other items discussed in this report are successfully tested using cryofracture, the hazard analysis will be updated to address that particular item. The cost for this activity is not considered significant and was, therefore, not included in the development of any economic analysis presented in this report.) However, labor costs to process the M16 series mines through the cryofracture facility were considered in any analysis where cryofracture is used. The prototype facility will feed cryofractured debris into an existing, environmentally permitted APE 1236 thermal treatment unit. Based on available information, the processing rate of the overall system will be limited by the amount of explosive that can be processed in the APE 1236.

In order to determine the processing rate for cryofracture, it was assumed throughout the study that the APE 1236 furnace could process no more than 5 lb of TNT (or equivalent) per flight. Since the amounts of TNT in each of the mines in the series varies from 1.13 lb of TNT for the M16A1 to 1.15 lb for the M16 to 1.3 lb of TNT for the M16A2, debris from four M16 or M16A1 mines could be fed into a flight at one time. The results of the evaluation would determine if debris from four M16A2 mines (5.2 lb TNT) could be fed into the furnace at one time. Another factor to consider in determining the processing rate of the current stockpile using cryofracture is the frequency at

which debris could be fed to a flight. This frequency is dependent on factors such as the configuration (contained or loose) and actual composition of the energetic materials. For this study, it was also assumed that the amount that can be fed per flight into the APE 1236 is equal to the amount that can be fractured in one-press cycle. The cryofracture system will operate at a rate of one-press cycle per minute, and the facility will run on a 500 min.-shift basis (1-10-4). (Before actually processing any munition in an APE 1236 furnace, an evaluation will need to be conducted to establish actual feed rates and allowable energetic quantities that can be safely processed without causing an incident and subsequent damage to the furnace.) The quantity of M16 series mines that are available for demil is 2,355,453 mines, as reported in May 1996. Using the proceeding information, the following is the rate at which mines could be processed through the APE 1236:

$$(4 \text{ mines/press cycle}) \times (1 \text{ press cycle/min.}) \times (500 \text{ min./shift}) \times (4 \text{ shifts/week}) = 8,000 \text{ mines/week}$$

or

$$2,355,453 \text{ mines} \times 1 \text{ week}/8,000 \text{ mines} \times 1 \text{ year}/50 \text{ plant working weeks} = 5.9 \text{ years to demilitarize all of the mines}$$

After processing the mines through the APE 1236, the remaining metals would be conveyed to a hopper where the metals could be separated into three piles: iron; steel (the most abundant metals from this item); and a pile for the remaining zinc, tin, and aluminum. These metals could then be removed and sold for scrap. The projected value of the metals was calculated and is shown below. Average amounts were used for the steel (0.783 lb), iron (4.51 lb), and the remaining metals (0.701 lb) because no data was found to exist on the quantities of each type of mine (M16, M16A1, and M16A2) to be demilled and because the weights of components vary from mine to mine. The following reclamation values were developed using scrap values of \$0.06/lb for steel and iron, \$0.0025 for mixed metals, and an assumed recovery rate of 90% for the metals*.

Steel

$$0.783 \times 2,355,453 \times 0.9 \times \$0.06 = \$99,593$$

Iron

$$4.51 \times 2,355,453 \times 0.9 \times \$0.06 = \$573,647$$

Mixed metals

$$0.701 \times 2,355,453 \times 0.9 \times \$0.0025 = \$3,715$$

Total value of reclaimed materials - \$676,955 (uninflated)

The cost of LN2 to support the cryofracture of 2,355,453 M16 series mines is as follows:

Based on prior cryogenic work performed by ARDEC and General Atomics, it is estimated that 0.5 lb of liquid nitrogen (LN2) is required to cryocool 1 lb of material.

$$0.5 \text{ lb of LN2} = 0.075 \text{ gal. LN2}$$

Using \$0.25/gal.gallon for LN2 and 8.25 lb/M16 mine (M16 weight from TM 43-0001-36)

$$2,355,453 \text{ mines} \times 8.25 \text{ lb/mine} \times 0.075 \text{ gal. LN2/lb mine} \times \$0.25/\text{gal. LN2} = \$388,650 \text{ in LN2 costs}$$

*All money in this report is from FY 98.

Labor cost for cryofracture:

The FY 98 McAlester AAP hourly rate for demil operations is \$88.52.

Using 1,740 hrs per operator for a working year and six operators per shift (four to operate the cryofracture system and two to separate the metals)

$\$88.52/\text{hr} \times 1,740 \text{ hrs/operator} \times 5.9 \text{ years to demilitarize} \times 6 \text{ operators/year} =$
 $\$5,452,478$ in labor costs to demilitarize the mines using cryofracture

Total cost for cryofracture without explosive recovery:

Labor	-	Recovered Metal	+	LN2	=	Total Cost
\$5,452,478	-	\$676,955	+	\$388,650	=	\$5,164,173 (uninflated)
						or \$2.19/M16 mine

Autoclave/Melt-out with Explosive Recovery

If, in addition to the recovery of the metals, recovery of the TNT is desired, the use of an autoclave or similarly designed melt-out system could be used to reclaim the TNT. With this process (fig. 3), the mine would need to be disassembled before any other processing could occur. In order to disassemble the mine, the fuze plug would need to be removed and the top lid would need to be cut off to allow for access to the internal components. Once the lid has been removed, the inner casing can be taken out and the body removed from the inner casing. After removing the propelling

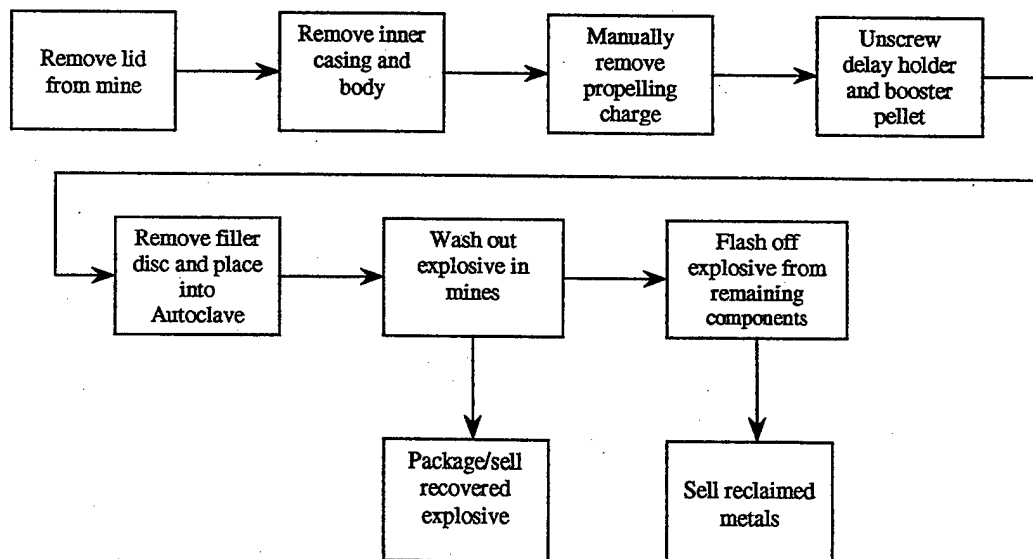


Figure 3
Recovery of TNT via autoclave/melt-out system

charge, the delay holder can be unscrewed and the booster pellet can then be removed from the base of the fuze well assembly. At this point, the filler disc at the top of the fuze well assembly can be removed and the bodies manually placed into the autoclave, with the filler hole facing down, to

melt out the explosive. The body would be processed until the TNT is melted out and collected in a catch pan. Because of the configuration of the body, the mine may need to be manipulated to pour out any TNT that remains in the body or the system could be designed to tilt the mine during melt out to maximize the amount of TNT that is recovered. After solidification, the TNT collected in the catch pan could then be packaged for resale or requalified to determine if it could be reused in other munitions. The remaining body/well assembly could then be sent to an APE 1236 furnace to flash off any remaining TNT residue. An evaluation will need to be conducted to establish actual rates and capacities for the destruction of all explosive items. After certification that all energetic materials have been removed, the remaining metal components could be separated and sold for scrap.

Equipment and labor estimate for autoclave/melt-out:

- Lid removal – 2 operators + \$50,000 for equipment
- Remove inner casing – \$50,000 for equipment
- Remove inner body – \$50,000 for equipment
- Remove propelling charge – 1 operator
- Unscrew delay holder - \$50,000 for equipment
- Remove booster pellet – 2 operators
- Remove filler cover/place mines in and remove from autoclave – 4 operators
- Autoclave/melt-out system - \$1,000,000
- Remove pans w/melted TNT – \$50,000 for equipment (scale, conveyor, etc.)
- Pack and transfer mines to 1236 for flashing – 4 operators
- Package reclaimed TNT – 4 operators
- Separate metals after flashing – 2 operators
- Conveyors not addressed – \$50,000

Total estimated equipment costs: \$1,300,000

Total estimated labor requirement: 19 operators

Using an estimated cycle time of 15 min. per batch and 32 mines per batch, the following processing rate for the M16 series mines was established:

$32 \text{ mines/batch} \times 1 \text{ batch/15 min.} \times 500 \text{ min./shift} \times 4 \text{ shifts/week} = 4,266 \text{ mines/week}$

or

$2,355,453 \text{ mines} \times 1 \text{ year/50 weeks} \times 1 \text{ week/4,266 mines} = 11.04 \text{ years to demilitarize all M16 mines using an autoclave system to recover the TNT}$

Labor cost:

Average operator rate is \$88.52/hr

Using 1,740 hrs/operator for a working year and 19 operators per shift:

$\$88.52/\text{hr} \times 1,740 \text{ hrs/operator} \times 11.04 \text{ years to demilitarize} \times 19 \text{ operators/year} =$
 $\$32,308,242 \text{ in labor costs to demilitarize the mines and recover the components using the autoclave system.}$

Material Recovery

The rationale and values used in the evaluation of the cryofracture process to calculate material recovery were also applied to this process. In addition to those values, the average amount used for the TNT main charge is 1.19 lb with an estimated recovery rate of 80%.

TNT	$1.19 \times 2,355,453 \times 0.8 \times \$0.35 = \$784,837$
Steel	$0.783 \times 2,355,453 \times 0.9 \times \$0.06 = \$99,593$
Iron	$4.51 \times 2,355,453 \times 0.9 \times \$0.06 = \$573,647$
Mixed metals	$0.701 \times 2,355,453 \times 0.9 \times \$0.0025 = \$3,715$

Total value of reclaimed materials = \$1,461,792 (uninflated)

Total cost for the autoclave/melt-out with explosive recovery:

$$\begin{array}{rclcl} \text{Labor} & + & \text{Equipment} - \text{Recovered Materials} & = & \text{Total Cost} \\ \$32,308,242 & + & \$1,300,000 - \$1,461,792 & = & \$32,146,450 \text{ (uninflated)} \\ & & & & \text{or } \$13.65/\text{M16 mine} \end{array}$$

Cryofracture with Explosive Recovery

The cryofracture process (fig. 4) could be used to separate the explosive from the mine. After fracturing the mines in the press, the debris can be placed onto a vibrating conveyor. As the debris travels along the belt, the item would separate further. At a point along the path, the debris would pass under a magnet, which would remove the ferrous metals. These metals would then be transported to the APE 1236 to flash off any energetic residue and sold for scrap. An evaluation will need to be conducted to establish actual rates and capacities for the destruction of all explosive items.

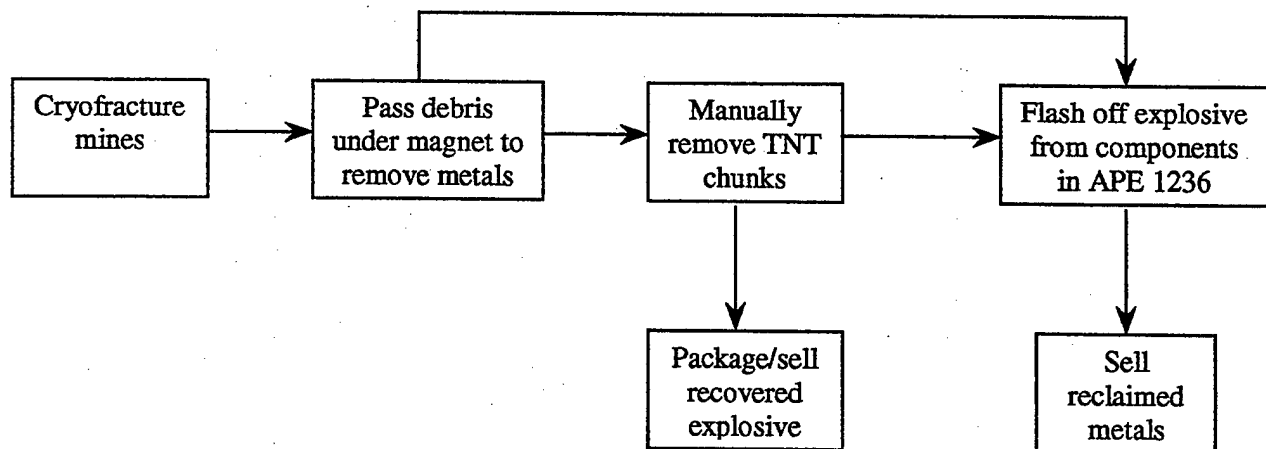


Figure 4
Recovery of TNT via cryofracture

The remaining debris on the conveyor would continue on the conveyor belt until it arrives at an area where the large chunks of TNT and large non-ferrous materials could be manually separated from the debris and placed into separate containers. The large chunks of TNT could then be sold commercially as a high grade TNT or requalified and reused in other munitions. The remaining debris, consisting of TNT, plastics, metals, and other energetic materials would then be transferred to an APE 1236 furnace for destruction and/or flashing with the remaining metals separated and sold for scrap.

An uncertainty that exists with this option is the behavior of the TNT after it has been processed through the cryofracture system. Although it is believed that the TNT will not "powderize" like pressed explosives after being processed through the cryofracture system, testing would need to be done to determine how the TNT will actually behave. As part of the testing of live mines in 3Q/4Q FY 98, a visual determination will be made as to the degree of breakup of the TNT. If the TNT does not powderize, then the use of this system could be considered. However, if the TNT does powderize, then this system should not be considered because of the difficulty in manually separating the powdered TNT from the rest of the cryofractured debris. For the economic evaluation of this process, it is assumed that the TNT will not powderize.

Equipment and labor estimate for cryofracture with explosive recovery:

5.9 yrs to demilitarize all of the mines (from earlier cryofracture description)

Average operator rate is \$88.52/hour

Using 1,740 hrs/operator for a working year, four operators to man the cryofracture process, two operators to separate the metals after flashing, and eight operators to man the additional stations required on a 1-10-4 shift basis (four for material separation, four to remove the material from the separation area, and packout the material)

$\$88.52/\text{hr} \times 1,740 \text{ hrs} \times 5.9 \text{ years to demilitarize} \times 14 \text{ operators} = \$12,722,448$ in labor costs to recover all components using cryofracture

Costs for equipment other than cryofracture system:

Vibrating conveyor – \$25,000

Magnet and ancillary equipment to remove ferrous metals – \$50,000

Equipment to separate TNT - \$50,000 (table, containers, container removal system)

Facility modifications to allow for explosive operations – \$200,000 (deluge, barricades, etc.)

Conveyors not discussed – \$50,000

Total estimated equipment costs - \$375,000

Total cost for the autoclave/melt-out with explosive recovery:

Labor	+	Equipment - Recovered Materials	+	LN2	=	Total Cost
\$12,722,448	+	\$375,000	-	\$1,461,792	+	\$388,650 = \$12,024,306
						(uninflated)
						or \$5.11/M16 mine

Conclusion

The following table summarizes the economics of each process considered.

Summary of demilitarization costs for the M16 series land mines

Demilitarization method	Labor cost (\$M)	Equipment cost (\$M)	Material recovery LN2 (\$M)	Cost to Government (\$M)
Cryofracture	5.45	0	0.29	5.16
Autoclave/melt-out w/TNT recovery	32.31	1.30	1.46	32.15
Cryofracture w/ TNT recovery	12.72	0.38	1.07	12.02

When the economics of each of the processes discussed are reviewed, it can be seen that the process that results in the least cost impact to the Government is the cryofracture process. Although the other two processes provide for reclamation of the TNT in addition to metals, the costs associated with each of those processes are significantly greater, especially with regard to projected labor costs. For this reason, cryofracture is the recommended method to demilitarize the M16 series mines.

M26 ANTIPERSONNEL LAND MINE

Item Description

The M26 mine (fig. 5) is a small, integrally fuzed, bounding type antipersonnel mine that is used when an effective above ground fragmentation pattern is required. The body of the mine is made of die-cast aluminum and is relatively cylindrical in shape. Some of the main components of the mine are the safe and arming (S&A) device, a fragmenting ball assembly consisting of a steel ball which contains an explosive charge, a delay and booster assembly recessed within the explosive charge, and an optional trip wire spool assembly that consists of four 20-ft trip wires.

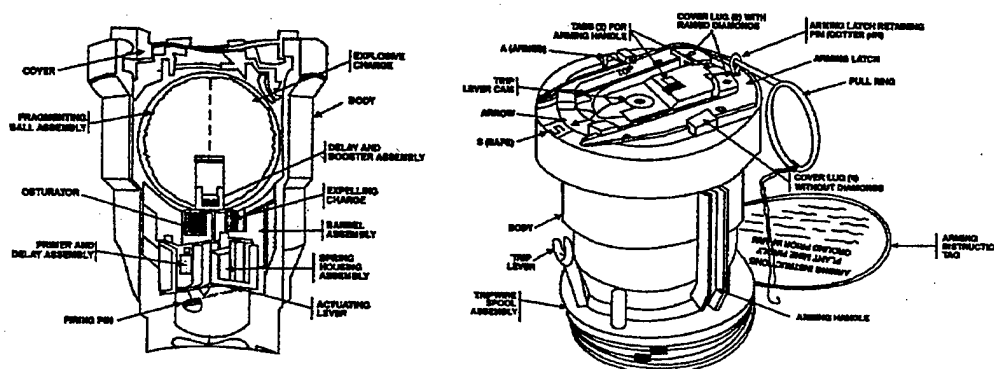


Figure 5
M26 antipersonnel mine

On the rim, at the top of the body, are two recesses with a raised S for safe and a raised A for armed. The cover is built with six lugs and the prongs of the arming latch fit between these to prevent rotation. The middle prong of the arming latch fits under the trip lever cam. The arming latch is attached to the body by an arming latch retaining pin. This pin is locked after insertion by spreading the ends.

Once the arming latch is removed and the mine is set to the armed position, a force of 14 to 28 lb on the mine top or a pull on the top lever will activate the mine. The mine may also be rigged for tripwire activation. Upon actuation, the spring-loaded firing pin is released and fires the primer and delay assembly, which in turn ignites the expelling charge. This charge ejects the fragmenting ball assembly to a height of approximately 2 m. The delay, ignited by the expelling charge, then ignites the booster, which detonates the main charge shattering the fragmenting ball.

Demilitarization Methods

The technologies reviewed for the M16 series mines (SCWO, plasma arc, and cryofracture) were also reviewed for applicability to the M26 mine. The SCWO and plasma arc were eliminated from consideration for the same reasons as for the M16 series mines. As a result, and because of the test results on similar sized items, cryofracture was determined to be the best candidate technology to demilitarize the M26 mine. However, testing would need to be conducted to ensure that cryofracture could be used. In addition, there is a concern of processing large quantities of aluminum through the APE 1236 furnace. A method to control the liquid aluminum would have to be developed.

Cryofracture

As stated, no testing has been conducted to establish the feasibility of using cryofracture to demilitarize the M26 mine. A test program at an estimated cost of \$300k is recommended using the test fixture at Dugway Proving Ground (DPG), Dugway, Utah to verify the feasibility of using cryofracture to demilitarize the M26 mine and also establish processing parameters such as time in the cryobath, press crush height, and item orientation. An additional effort is required to evaluate methods to control/handle the solidification of liquid aluminum on the output conveyor of the APE 1236 furnace. Upon completion of the feasibility tests, the processing parameters would then be transferred to the database of the cryofracture facility being developed for implementation at McAlester AAP. Before actually processing the M26 mine in an APE 1236 furnace, an evaluation will be conducted to establish actual feed rates and allowable energetic quantities that can be safely processed without causing an incident and subsequent damage to the furnace. Using the parameters identified for the M16 mines, a projection can be made to estimate the processing rate using cryofracture. Using the assumed explosive design limits of the APE 1236 furnace [maximum 5 lb of TNT (or equivalent) per 1236 flight], up to 11 mines could be fed into each flight.

Each M26 mine contains 0.375 lb of Composition B as the main charge. From TM 9-1300-214, 1 lb of Comp B is equal to 1.16 lb of TNT. Therefore, 5 lb of TNT is equal to 4.3 lb of Comp B.

$$1 \text{ mine}/0.375 \text{ lb Comp B} \times 4.3 \text{ lb of Comp B/flight} = 11 \text{ mines/flight}$$

Using the same assumptions that were made for the M16 series mines—that is, the amount that can be fed per flight into the APE 1236 is equal to the amount that can be fractured in one-press cycle, the cryofracture system will operate at a rate of one-press cycle per minute, and the facility will run on a 500 min. shift basis (1-10-4)—the demilitarization of the M26 mine would require the following:

$$(11 \text{ mines/press cycle}) \times (1 \text{ press cycle/min.}) \times (500 \text{ min./shift}) \times (4 \text{ shifts/week}) = 22,000 \text{ mines/week}$$

or using the available quantity (22,416) of M26 mines as reported in May 1996,

$$22,416 \text{ mines} \times 1 \text{ week} / 22,000 \text{ mines} \times 1 \text{ year} / 50 \text{ plant working weeks} = 0.02 \text{ years (1.02 weeks) to demilitarize all of the mines}$$

Using an average operator rate (from munitions handler rate projected for FY 98 for McAlester AAP) of \$88.52/hr, 1,740 hrs per operator for a working year and six operators per shift, the following labor costs have been projected:

$$\$88.52/\text{hr} \times 1,740 \text{ hrs/operator} \times 0.02 \text{ years to demilitarize} \times 6 \text{ operators/year} = \$18,483 \text{ in labor costs to demilitarize the M26 mine using cryofracture}$$

As with the M16 series mines, after processing the M26 mines through the APE 1236 furnace the remaining metals would be conveyed to a hopper where the metals could be removed, separated, and sold for scrap. The M26 mine contains the following amounts of metals: aluminum – 1.38 lb, steel - 0.301 lb, and copper – 0.001 lb. The estimated reclamation values were developed using scrap values of \$0.06/lb for steel, \$0.45/lb for aluminum, and \$0.80/lb for copper and an assumed recovery rate of 90% for the metals.

Aluminum

$$1.38 \text{ lb/mine} \times \$0.45/\text{lb} \times 22,416 \text{ mines} \times 0.9 = \$12,528$$

Steel

$$0.301 \text{ lb/mine} \times \$0.06/\text{lb} \times 22,416 \text{ mines} \times 0.9 = \$364$$

Copper

$$0.001 \text{ lb/mine} \times \$0.80/\text{lb} \times 22,416 \text{ mines} \times 0.9 = \$16$$

Total value of reclaimed materials - \$12,908 (uninflated)

The cost of LN2 to support the cryofracture of 22,416 M26 series mines is as follows:

Based on prior cryogenic work performed by ARDEC and General Atomics, it is estimated that 0.5 lb of liquid nitrogen (LN2) is required to cryocool 1 lb of material.

$$0.5 \text{ lb of LN2} = 0.075 \text{ gal. LN2}$$

Using \$0.25/gal. for LN2 and 3.5 lb/M26 mine (M26 weight from TM 43-0001-36):

$$22,416 \text{ mines} \times 3.5 \text{ lb/mine} \times 0.075 \text{ gal. LN2/lb mine} \times \$0.25/\text{gal. LN2} = \$1,569 \text{ in LN2 costs}$$

Using the figures presented, the total cost to demilitarize the M26 mine using cryofracture is calculated as follows:

$$\begin{array}{rclcl} \text{Testing} & + & \text{Labor} & - & \text{Metal Recovery} & + & \text{LN2} & = & \text{Total Cost} \\ \$300,000 & + & 18,483 & - & 12,908 & + & 1,569 & = & \$307,144 \text{ (uninflated)} \\ & & & & & & & & \text{or } \$13.83 / \text{M26 mine} \end{array}$$

Explosive Recovery Methods

Because of its relatively small size, the mine contains only 0.375 lb of Composition B as the main explosive charge. When coupled with the low number of mines, and assuming a recovery rate of 80%, only 6,725 lb of Comp B would be able to be recovered.

$$0.375 \text{ lb/mine} \times 22,416 \text{ mines} \times 0.8 = 6,725 \text{ lb of Comp B}$$

If the disassembly of the item were desired in order to recover the explosive, it would require that the cover be pulled out of the body in order to access the fragmenting ball assembly. This assembly would then need to be broken apart to extract the Comp B. When the amount of equipment development to perform these activities is envisioned along with the associated costs, it can be clearly seen that the cost and effort required to recover the Comp B far exceeds the value of the material as shown in the following section and is therefore not worth pursuing.

$$\text{Value of Comp B: } \$0.48/\text{lb} \times 6,725 \text{ lb} = \$3,228$$

Conclusion

Based on the small number of mines available for demil, it is recommended that cryofracture without explosive recovery be considered as an alternative to OB/OD for the destruction of the M26 mine.

M14 ANTIPERSONNEL LAND MINE

Item Description

The M14 antipersonnel mine (fig. 6) is a blast-type mine and is used when small, non-detectable, readily concealed mines are required. The mine is of practically all-plastic construction and non-detectable by magnetic mine detectors. A pressure plate is designed to transfer the load to a firing pin mounted on a belleville spring. When the load reaches a pre-determined value (20 to 35 lb), the belleville spring snaps into a reverse position, driving the steel firing pin into the detonator and setting off the main charge. The pressure plate has a yellow indicating arrow, which points to either "A" or "S" to indicate whether the mine is armed or safe.

In addition to the S&A indication, a U-shaped safety clip is inserted into slots in the pressure plate to prevent accidental depression of the pressure plate during handling or shipping. A pull cord is provided for removing the clip when arming the mine. For safety during shipment, the plastic detonator holder assembly with detonator is packaged separately within the same shipping container. A hole in the bottom of the mine, which accommodates the detonator holder assembly, is closed by a plastic plug.

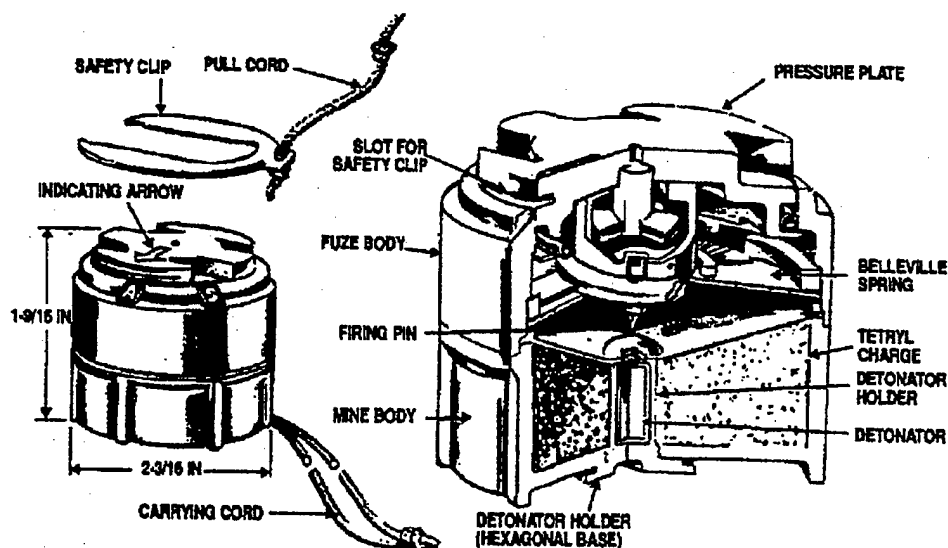


Figure 6
M14 nonmetallic antipersonnel mine

Demilitarization Methods

The technologies reviewed for the M16 series and M26 mines were also reviewed for the M14 mine. The SCWO was eliminated as a candidate to demilitarize the M14 mine for the same reasons it was eliminated for the other two mines. The plasma arc technology, however, has potential as a demilitarization method for the M14 mine. Because the majority of the mine is plastic and has a small (1 oz) explosive charge, it would have a lesser potential to damage the unit than the other two mines. Before plasma arc could be given serious consideration as a potential method to demilitarize the M14 mine, an assessment of the design specifications of the plasma arc system versus the energy level produced by the mine would need to be conducted. If the results of the assessment are favorable, testing using live items to verify the results of the assessment would need to be conducted. Although cryofracture testing of this mine has not been conducted to verify the ability to demilitarize the M14 mine, the results from testing other, similar items indicates a high probability of success. For this reason, cryofracture is considered to be the most promising technology of those considered.

Cryofracture

As stated, no testing has been conducted to establish the feasibility of using cryofracture to demilitarize the M14 mine. A test program at an estimated cost of \$300k is recommended using the test fixture at DPG, Dugway, Utah to verify the feasibility of using cryofracture to demilitarize the M14 mine and also establish processing parameters such as time in the cryobath, press crush height, and item orientation. An additional effort is required to evaluate methods to control/handle liquid aluminum in the APE 1236 furnace. Upon completion of the feasibility tests, the processing parameters would then be transferred to the database of the cryofracture facility being developed for implementation at McAlester AAP. Before actually processing the M14 mine in an APE 1236 furnace, an evaluation will be conducted to establish actual feed rates and allowable energetic

quantities that can be safely processed without causing an incident and subsequent damage to the furnace. An additional evaluation will be needed to establish the levels of plastic residue that the pollution abatement equipment can accommodate. Using the parameters identified for the M16 and M26 mines, a projection can be made to estimate the processing rate using cryofracture. Using the assumed explosive design limits of the APE 1236 furnace [maximum 5 lb of TNT (or equivalent) per 1236 flight], up to 64 mines could be fed into each flight. An evaluation will need to be conducted to establish actual rates and capacities for the destruction of all explosive items.

Each M14 mine contains 1 oz of tetryl as the main charge. From TM 9-1300-214, 1 lb of tetryl is equal to 1.23 lb of TNT. Therefore, 5 lb of TNT is equal to 4 lb of tetryl.

$$1 \text{ mine/oz of tetryl} \times 16 \text{ oz/lb} \times 4 \text{ lb of tetryl/flight} = 64 \text{ mines/flight}$$

Using the same assumptions that were made for the M16 series and M26 mines—that is, the amount that can be fed per flight into the APE 1236 is equal to the amount that can be fractured in one-press cycle, the cryofracture system will operate at a rate of one-press cycle per minute and the facility will run on a 500 min. shift basis (1-10-4)—the demilitarization of the M14 mine would require the following:

$$(64 \text{ mines/press cycle}) \times (1\text{-press cycle/min.}) \times (500 \text{ min./shift}) \times (4 \text{ shifts/week}) = 128,000 \text{ mines/week}$$

or using the available quantity (5,551,703) of M14 mines as reported in May 1996 report,

$$5,551,703 \text{ mines} \times 1 \text{ week/128,000 mines} \times 1 \text{ year/50 plant working weeks} = 0.87 \text{ years to demilitarize all of the mines}$$

Using an average operator rate (from munitions handler rate projected for FY 98 for McAlester AAP) of \$88.52/hr, 1,740 hrs/operator for a working year and four operators per shift, the following labor costs have been projected:

$$\$88.52/\text{hr} \times 1,740 \text{ hrs/operator} \times .87 \text{ years to demilitarize} \times 4 \text{ operators/year} = \$536,006 \text{ in labor costs to demilitarize the mines using cryofracture}$$

As with the M16 series and M26 mines, after processing the mines through the APE 1236 furnace, the remaining metals would be conveyed to a hopper where the metals could be removed and sold for scrap. Of the materials that are not energetic, the only material that has any reclamation value is steel. There are 0.263 oz of steel in each mine. Assuming a recovery rate of 90% and a scrap value of \$0.06/lb for steel, the amount and value of steel that could be reclaimed is as follows:

$$0.263 \text{ oz of steel/mine} \times 1 \text{ lb/16 oz} \times 5,551,703 \text{ mines} \times 0.9 = 82,130 \text{ lb of steel}$$

$$82,130 \text{ lb} \times \$0.06/\text{lb} = \$4,928 \text{ for the reclaimed steel}$$

The cost of LN2 to support the cryofracture of 5,551,703 M14 series mines is as follows:

Based on prior cryogenic work performed by ARDEC and General Atomics, it is estimated that 0.5 lb of liquid nitrogen (LN2) is required to cryocool 1 lb of material.

$$0.5 \text{ lb of LN2} = 0.075 \text{ gal. LN2}$$

Using \$0.25/gal. for LN2 and 0.208 lb/M14 mine (M14 weight from TM 43-0001-36):

5,551,703 mines x 0.208 lb/mine x 0.075 gal. LN2/lb mine x \$0.25/gallon LN2 = \$29,109 in LN2 costs

Using the figures presented, the total cost to demilitarize the M14 mine using cryofracture is calculated as follows:

Labor	+	Testing	-	Steel Recovery	+	LN2	=	Total Cost
\$536,006	+	300,000	-	4,928	+	29,109	=	\$860,187 (uninflated)
								or \$0.15/M14 mine

Explosive Recovery

Although there is a large number of M14 mines to be demilled, any activities to disassemble the mine and recover the energetic materials were not considered. This decision is based on the fact that tetryl, the main charge and largest component by weight, currently has no resale value since the United States discontinued the use of tetryl in 1979 for new items and initiatives were undertaken to redesign existing items to use alternative explosives.

Conclusion

Despite the fact that it would not result in a cost benefit to the government, cryofracture is considered to be the best candidate technology to demilitarize the M14 mine. This conclusion is based on the available information on cryofracture and because of the lack of information regarding the ability to process explosive loaded items through the plasma arc unit. If the interest and funding exists to conduct a test program for the M14 mine using cryofracture and also a plasma arc system, the results of that testing would be used to compare the two technologies to further establish the best method to demilitarize the M14 mine.

FAMILY OF SCATTERABLE ANTIPERSONNEL MINES

Item Description

The FASCAM family of self-destructing scatterable mines contains both antiarmor and antipersonnel (AP) mines that are either hand emplaced, delivered by aircraft, or special purpose ground vehicles. The FASCAM family of AP mines uses many common parts and functions to minimize tooling and production costs. The main difference is the electronics, which are designed to meet the differing deployment conditions. The kill mechanism is identical in the ground emplaced mine scattering system (GEMMS), air delivered AP/AV target activated munition system (GATOR), and multiple delivery mine system (VOLCANO) AP mines. Because of the similarities in design, the GEMMS M74 AP mine was evaluated for potential demil procedures other than OB/OD. The following list summarizes the family of FASCAM mines:

<u>Nomenclature</u>		<u>Mine type</u>	<u>Delivery method</u>	<u>DODIC No.</u>
GEMMS	M74	AP	M128 towed dispenser	K151
(app A)*	M75	antiarmor		K184

<u>Nomenclature</u>		<u>Mine type</u>	<u>Delivery method</u>	<u>DODIC No.</u>
MOPMS (app B)*	M131	antiarmor	2-man hand employed (17AT/4AP)	K022
	M132	AP		
GATOR (AF/NAVY)	BLU91	antiarmor	AF-CBU 89/B dispenser Navy-CBU 78/B dispenser (aircraft)	Multiple
	BLU92	AP		
VOLCANO (app C)*	M89		XM87 Canister (5AT/1AP) (Launch racks-M817 dump truck or UH60 blackhawk helicopter)	K042 & K045

*Description from TM 43-001-36.

General

The M74 AP mine is a 4.75-in. diameter, 2.6-in. high disc shaped, tripwire activated, ground burst, fragmenting AP mine weighing approximately 3.1 lb. There are four external tripwire exit holes at each end of the mine. The M74 is an electronically operated self-destruct mine having both mechanical and electrical arming features. Primary functioning is by tripwire sensor, four of which are deployed from the mine end facing the target. An antidisturbance feature is also provided. The mine self-destructs at one of two selectable times, set by the dispenser as it exits the launcher. The mine will also function if its power supply voltage drops to a low level.

Currently (Aug 97), there is a moratorium on the export of AP mines to foreign countries. There is also mounting political pressure to outlaw the use of AP mines, especially those without a self-destruct feature. Although the FASCAM mines have a self-destruct feature, Lone Star AAP has downloaded the XM87 canister and replaced the one AP mine with one AT mine. In addition, the Industrial Operations Command (IOC) has scheduled the demilitarization of 6,000 M74 AP mines in FY 98. The following chart is an estimate of the FASCAM AP mines as reported in May 1996:

<u>Nomenclature</u>	<u>DODIC no.</u>	<u>Units</u>	<u>No. AP/unit</u>	<u>No. AP mines</u>
GEMMS	K151	71,200	1	71,200
MOPMS	K022	2,300	4	9,200
GATOR	Multiple			
CBU 89/B		10,955	22	241,010
CBU 78/B		3,323	15	49,845
VOLCANO	K045	107,300	1	107,300

Design

Figure 7 shows a blow up illustration of the FASCAM (BLU-92B) AP components. The M74 AP mine is composed of two major assemblies: the kill mechanism (warhead) and body assembly. The kill mechanism consists of an outer tube shaped steel case (fenn mill embossed) and an inner

steel liner, which contains approximately 0.826 lb of Composition B4 explosive and four Composition A5 booster pellets (0.0139 lb). The body assembly is located in the center of the mine and contains the operational elements of the mine. It consists of a number of molded parts which are ultrasonically welded together and provide cavities for the electronics, lithium reserve cells, S&A assembly, electric battery primer, signal receiver coil, tripline sensors, electric pressure cartridge, and explosive leads. Flexible cables accomplish all electrical connections. The assembly contains two main molded plastic housings (upper housing and lower power supply housing) that are ultrasonically welded together by three steel weld posts. The upper housing contains four tripwire sensors. The power supply housing contains four tripwire sensors and a bonded electric battery primer. Two lithium batteries with lead assemblies are bonded into the power supply-housing cavity and are sealed by the power supply cover and receiver coil. Four explosive leads (PA509) in lead holders are bonded between the electronic flex assembly and the power supply plate. The S&A assembly sits inside the cavity formed by the two housings and is soldered to the electronic flex assembly. The pressure cartridge is bonded onto the electronic flex assembly. Brief descriptions of the body assembly parts follow:

Electronics – Provides timing and firing functions for final S&A and electronic arming, tripline deployment, and mine firing.

Lithium reserve cells – Two cells connected in series provide electrical power.

S&A assembly – Provides out-of-line explosive safety and contains the explosive train electrical detonator.

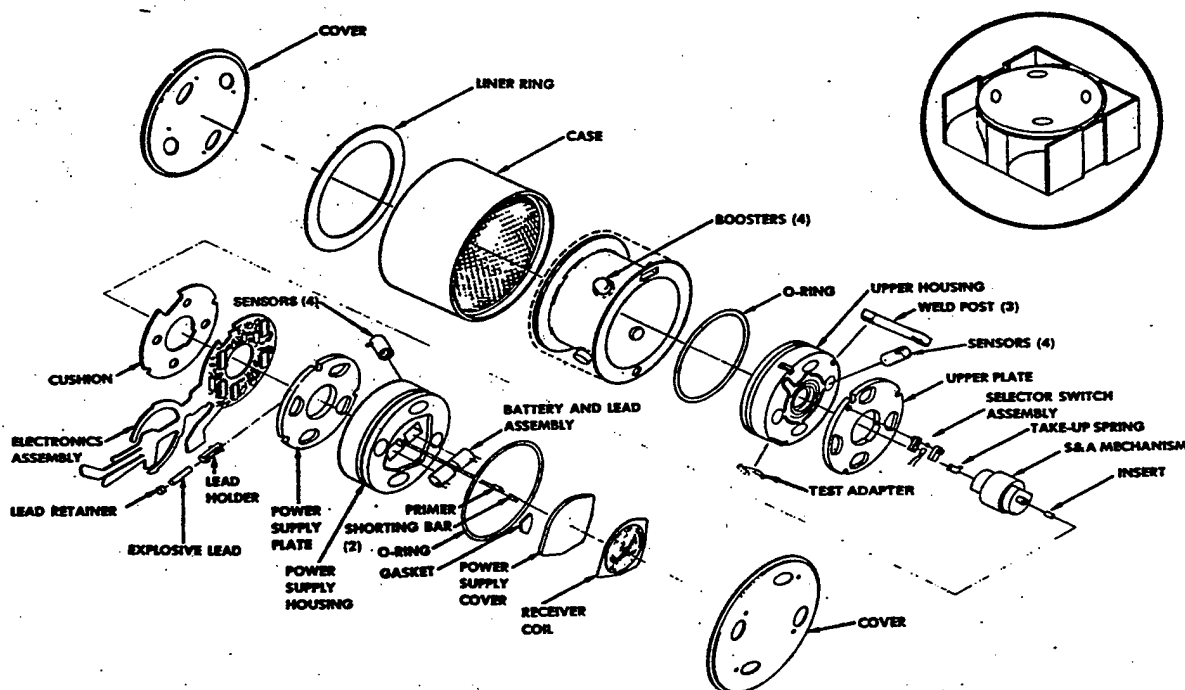


Figure 7
BLU-92/B GATOR mine – exploded view

Electric battery primer – Blast output activated lithium battery, enables arming of S&A and breaks electrical short of the electronics circuit.

Receiver coil – Receives signal from dispenser which fires the electric battery primer and sets self-destruct time.

Tripline sensor – Senses tripline pull and transmits signal to the electronics assembly. Eight sensors (four/side) are located in the mine.

Electric pressure cartridge – Provides gas pressure to deploy triplines.

Explosive leads – Four leads provide explosive output from the S&A to the booster pellets.

M74 AP mine explosives components

<u>Component</u>	<u>Explosive type</u>	<u>Explosive weight (g)</u>
Kill Mechanism:		
Explosive Charge	Comp. B4	375.000
Booster Pellets (4 each)	Comp. A5	6.320
Body Assembly:		
Explosive Lead, PA509 (4)	PBXN-5	4.000
Pressure Cartridge	Calcium Chromate & Boron	0.028
Primer, Battery Electric	Barium Nitrate & Lead Azide	0.023 & 0.018
Lithium Battery	Lithium Electrolyte Thionyl Chloride – MIL-L-48768	0.5 cc
S&A Assembly:		
Explosive Lead, PA517 (4)	PBXN-5	0.324
Explosive Lead, PA513	PBXN-5	0.275
Electrical Detonator M100	Lead Azide & HMX	0.014 & 0.016
Piston	Propellant Load Mix	0.004
Piston	Smokeless Powder	0.007
Ignitor Assembly	Spot Charge	0.001

Functioning

When the mine undergoes spin in the launcher, the centrifugal locks move out. As the mine exits the launcher, a magnetic coil in the mine picks up an electrical pulse, which fires the electric battery primer. The primer output activates the lithium battery, starts the mine electronics, and locks out the centrifugal locks in the S&A. As the mine is deployed, the S&A borerider is released removing the second safety. After the mine impacts the ground, the mine electronics assembly generates an arming signal bringing the S&A explosive train into line and initiating a pressure cartridge, which causes the ejection of the four tripwire assemblies. The mine is then armed. The mine will function to any of the following conditions: movement of a tripwire, physical disturbance of the mine, expiration of the self-destruct time, or power rundown.

Demil Procedure

Two demil alternatives considered were disassembly and cryofracture.

Disassembly Demil Alternative

The steps for the disassembly demil alternative are:

1. Unpack mine
2. Separate kill mechanism from body assembly
3. Manually remove/washout/dissolve the four Composition A5 booster pellets from kill mechanism
4. Cut or punch the kill mechanism to expose B4 explosive
5. Incinerate exposed kill mechanism in rotary kiln furnace
6. Reclaim steel
7. Feed body assembly into rotary kiln furnace
8. Dispose furnace slag

The kill mechanism (warhead) can be separated from the body assembly. The cover plates can be popped off after removing the eight outside screws from the covers. The body assembly can then be pushed out of the kill mechanism using a hydraulic press. The kill mechanism contains 1.286 lb of steel, 0.826 lb of Composition B4 explosive, and four Composition A5 pellets that are taped into the inner wall recesses of the steel case. The kill mechanism is then cut or punched to expose the Composition B4 so it will not detonate in the incinerator. The four booster pellets may have to be removed prior to incineration. They have a tight fit and can be steamed out or dissolved in a solution prior to exposing the Composition B4 explosive.

The simplest and most economical demilitarization method for the body assembly is to feed the complete assembly into an incinerator such as the APE 1236 rotary kiln. As shown in the previous table, the body assembly contains approximately 5 g of explosive materials (explosive leads, detonators) and lithium batteries. There is a concern that lithium batteries cannot be incinerated in a rotary kiln. Separating the lithium batteries from the body assembly is difficult due to their location in the body assembly. If battery or explosive lead assembly removal from the body assembly is required for incineration, the following procedure is proposed. The three ultrasonically welded posts of the body assembly can be removed, the two plastic housing halves separated, and the S&A assembly removed by cutting the leads to the flex assembly. The flex assembly can then be removed. The lead assemblies can then be pried out leaving the power supply housing with the two lithium batteries and M100 electrical detonator.

Because no testing has been conducted to date to establish a non-OB/OD process to demilitarize FASCAM mines, a study at an estimated cost of \$300k to define the special safety handling procedures and equipment for the FASCAM disassembly is recommended. An additional

study, also at an estimated cost of \$300k, to evaluate systems such as an APE 1236 furnace or a plasma arc furnace for destruction of the body assembly, kill mechanism, and lithium battery is recommended. This study would include an evaluation to establish processing criteria so that these components can be safely processed without causing an incident and subsequent damage to the to-be-evaluated system(s).

This procedure would require facility equipment for disassembly, kill mechanism cutting, and an APE 1236 rotary kiln for incinerating the kill mechanism and body assembly. Assuming the availability of an APE 1236 rotary kiln, the following are equipment and labor estimates for this alternative:

Unpack and remove AP mines: 2 operators
Separate kill mechanism and body assembly: 2 operators + \$100,000 for equipment
Cut/punch kill mechanism: 4 operators + \$100,000 for equipment
Rotary kiln operators: 2 operators

Totals:
Labor requirement – 10 operators
Equipment - \$200,000

Cost estimate:

The facility will run on a 500-min. a shift basis (1-10-4). It is estimated that the cycle time is 60 min./batch and 30 minutes per batch. To perform an economic analysis it was assumed that 200,000 FASCAM AP mines are demilled. Using these assumptions, the following is the rate at which 200,000 mines could be processed:

$(30 \text{ mines/batch}) \times (1 \text{ batch/60 min.}) \times (500 \text{ min./shift}) \times (4 \text{ shifts/week}) = 1,000$
mines/week

$200,000 \text{ mines} \times 1 \text{ week/1,000 mines} \times 1 \text{ year/50 plant working weeks} = 4 \text{ years to}$
demil 200k mines

Using an average operator rate (from munitions handler rate projected for FY 98 for McAlester AAP) of \$88.52/hr, 1,740 hrs/operator for a working year and 10 operators per shift, the following labor costs have been projected:

$\$88.52/\text{hr} \times 1,740 \text{ hrs/operator} \times 4 \text{ years to demil} \times 10 \text{ operators/year} = \$6,160,992$
in labor costs to demil the mines.

The following table shows the estimated value of recovered steel from the demil processes. The estimated reclamation values were developed using an assumed recovery rate of 90%, 200k mines and a scrap value of \$0.06/lb for steel.

<u>Recovered component</u>	<u>Weight per mine (lb)</u>	<u>Dollar per lb</u>	<u>Value/mine</u>	<u>Total \$ value</u>
Steel	1.286	0.06	0.07	14,000

Using the figures presented, the total cost to demilitarize the FASCAM using the disassembly alternative is calculated as follows:

$$\begin{array}{rclcl}
 \text{Labor} & + & \text{Testing} & + & \text{Equipment} & - & \text{Steel Recovery} & = & \text{Total Cost} \\
 \$6,160,992 & + & 300,000 & + & 200,00 & - & 14,000 & = & \$6,646,992 \text{ (uninflated)} \\
 & & & & & & & & \text{or } \$33.30 / \text{FASCAM AP mine}
 \end{array}$$

Explosive Recovery

The M74 AP mine contains 0.826 lb of Composition B4 explosive. Composition B4 is 60% by weight RDX, 39% TNT, and 1% calcium silicate. Currently there are 60 million pounds of Composition B in storage [Conventional Ammunition Working Capital Fund (CAWCF) Industrial Account]. There are no known military buys for Composition B4. If the Composition B4 is recovered, it would be used for commercial sales (estimated price - \$0.48/lb).

The B4 explosive in the M74 kill mechanism is sealed in a steel case with four Composition A5 booster pellets taped into the case inner recesses. The two loading holes (sealed with a sleeve and plug) are too small to melt out the explosive. The following are the envisioned steps to recover the explosive from the kill mechanism:

1. Remove the aluminum tape from the A5 booster pellets
2. Dissolve or steam-out the A5 pellets
3. Cut (water jet) the kill mechanism lengthwise to expose the explosive
4. Melt out the B4 explosive (autoclave)
5. Flash the steel case segments

The value of the recovered explosive is calculated to be \$72,000 (0.826 lb/mine x \$0.48/lb x 90% recovery x 200k mines). The autoclave facilitation costs (\$1,000,000 est.) and labor costs to recover and process the B4 explosive would significantly exceed \$72,000, therefore the recovery of Composition B is not recommended.

Cryofracture Alternative

Cryofracture involves the freezing of the munition in liquid nitrogen bath, followed by fracture of the embrittled munition in a hydraulic press, and the subsequent thermal treatment of the fractured munition debris to destroy the explosives and decontaminate any residue metal parts (which may be recovered for scrap value). No testing has been conducted to establish the feasibility of using cryofracture to demil the FASCAM AP mine. A test program at an estimated cost of \$300k can be conducted to assess the use of cryofracture as a demil technology for FASCAM mines. Assuming the testing was successful, the McAlester AAP cryofracture facility could be modified as necessary to process FASCAM mines. For the cryofracture alternative it was assumed that the complete mine is cryofractured. If the test program shows that the body assembly must be separated from the kill mechanism, additional personnel and equipment will be required.

Economic Evaluation

The press capacity and cycle time and the capacity of the APE 1236 thermal treatment unit limit the production plant throughput. The previously assumed capacity of 5 lb TNT/APE 1236 flight was also used for the FASCAM mine. Each M74 mine contains 0.826 lb of Composition B4. One pound of Composition B is equal to 1.16 lb TNT. Therefore, 5 lb of TNT is equal to 4.3 lb of Composition B4, and thus 5 mines can be run per flight. An evaluation will need to be conducted to establish actual rates and capacities for the destruction of all explosive items. After processing the mines through the APE1236 furnace the flashed residue can be conveyed in hopper where the steel is recovered for scrap. The following assumptions were used to determine costs:

Hydraulic press cycle is one per 3 min.

Number of mines per press cycle is five

Unpacking and removing mines: two operators, operate cryogenic facility: four operators,
Rotary kiln operators: two operators

The facility will run on a 500-min. a shift basis (1-10-4). Using this assumption, the following is the rate at which the 200,000 mines could be processed:

$(5 \text{ mines/press cycle}) \times (1\text{-press cycle}/3 \text{ min.}) \times (500 \text{ min./shift}) \times (4 \text{ shifts/week}) = 3,333 \text{ mines/week}$

$200,000 \text{ mines} \times 1\text{week}/3,333 \text{ mines} \times 1 \text{ year}/50 \text{ plant working weeks} = 1.2 \text{ years to demil 200k mines}$

Labor costs:

Using an average operator rate (from munitions handler rate projected for FY 98 for McAlester AAP) of \$88.52/hr, 1,740 hrs/operator for a working year and eight operators per shift, the following labor costs have been projected:

$\$88.52/\text{hr} \times 1,740 \text{ hrs/operator} \times 1.2 \text{ years to demil} \times 8 \text{ operators/year} =$
 $\$1,478,000 \text{ to demil 200k mines.}$

Costs for equipment other than cryofracture facility:

Conveyors - \$100,000

Handling Equipment - \$100,000

Total - \$200,000

The cost of LN2 to support the cryofracture of 200,000 FASCAM mines is as follows:

Based on prior cryogenic work performed by ARDEC and General Atomics, it is estimated that 0.5 lb of liquid nitrogen (LN2) is required to cryocool 1 lb of material.

$0.5 \text{ lb of LN2} = 0.075 \text{ gal. LN2}$

Using \$0.25/gal. for LN2 and 2.2 lb/FASCAM mine (M26 weight from TM 43-0001-36)

200,000 mines x 2.2 lb/mine x 0.075 gal. LN2/lb mine x \$0.25/gal. LN2 = \$8,800 in LN2 costs

Using the figures presented, the total cost to demilitarize the FASCAM using the cryofracture alternative is calculated as follows:

Labor	+	Testing	+	Equipment	-	Steel Recovery	+	LN2	=	Total Cost
\$1,478,000	+	300,000	+	200,00	-	14,000	+	8,800	=	\$1,973,438
										(uninflated)
										or \$9.90/
										FASCAM AP
										mine

Conclusion

The following table summarizes the economics of each process considered.

Summary of demilitarization costs for the FASCAM land mines

Demilitarization method	Labor cost (\$M)	Equipment cost (\$M)	Study cost (\$M)	Material recovery – LN2 (\$M)	Cost to Govt. (\$M)
Disassembly	6.16	0.20	0.30	0.01	6.65
Cryofracture	1.48	0.20	0.30	0.0	1.97

When the economics of each alternative discussed are reviewed, it can be seen that the cryofracture process estimate is less expensive than disassembly. For this reason, cryofracture is the recommended alternative to OB/OD for demiling FASCAM AP mines. Note: Utility costs, transportation, and furnace slag disposal costs are not included. For each alternative, a study to establish feasibility and processing parameters is recommended.

CONCLUSIONS

The following tables summarize the costs and benefits of the demil alternatives considered as alternatives to open burning/open detonation (OB/OD) in this study. The cost estimates are based on the assumptions stated in the body of the report and will be refined after the completion of the recommended preliminary mine specific test programs. The preliminary test programs may identify additional furnace pre-treatment steps and alter process rates.

M16 series land mines - quantity - 2,355,453

Demilitarization method	Labor cost (\$M)	Equipment cost (\$M)	Material recovery LN2 (\$M)	Cost to government (\$M) \$/mine	
Cryofracture	5.45	0.0	0.29	5.16	2.19
Autoclave/melt-out w/TNT recovery	32.31	1.30	1.46	32.15	13.65
Cryofracture w/TNT recovery	12.72	0.38	1.07	12.03	5.11

The process that results in the least cost impact to the Government is the cryofracture process. Although the other two processes provide for reclamation of the TNT in addition to metals, the costs associated with each of those processes are significantly greater, especially with regard to projected labor costs. For this reason, cryofracture is the recommended method to demilitarize the M16 series mines.

M26 mine - quantity - 22,416

Demilitarization method	Labor cost (\$M)	Study cost (\$M)	Material recovery LN2 (\$M)	Cost to Government (\$M) \$/mine	
Cryofracture	0.02	0.30	0.01	0.31	13.83

Based on the small number of mines available for demil, it is recommended that cryofracture without explosive recovery be considered as an alternative to OB/OD for the destruction of the M26 mine.

M14 mine - quantity - 5,551,703

Demilitarization method	Labor cost (\$M)	Study cost (\$M)	Material recovery LN2 (\$M)	Cost to Government (\$M) \$/mine	
Cryofracture	0.53	0.30	-0.02	0.85	0.15

Cryofracture without explosive recovery is considered to be the best candidate technology to demilitarize the M14 mine. Although plasma arc technology was given more consideration than for the M16 and M26 mines, the lack of information regarding the ability to process explosive loaded items through the plasma arc unit precluded further evaluation at this time. If the interest and funding exists to conduct a test program for the M14 mine using cryofracture and also a plasma arc system, the results of that testing would be used to compare the two technologies to further establish the best method to demilitarize the M14 mine.

FASCAM AP mines - quantity – 200,000

Demilitarization method	Labor cost (\$M)	Equipment cost (\$M)	Study cost (\$M)	Material recovery –LN2 (\$M)	Cost to Government (\$M) \$/mine	
Disassembly	6.16	0.20	0.30	0.0	6.66	33.30
Cryofracture	1.48	0.20	0.30	0.01	1.98	9.90

When the economics of each alternative discussed are reviewed, it can be seen that the cryofracture process estimate is less expensive than disassembly. For this reason, cryofracture is the recommended alternative to OB/OD for demiling FASCAM AP mines. Prior to implementation, a study at an estimated cost of \$300K to evaluate systems such as an APE 1236 furnace or a plasma arc furnace for destruction of the body assembly, kill mechanism, and lithium battery is recommended. This study would include an evaluation to establish processing criteria so that these components can be safely processed without causing an incident and subsequent damage to the to-be-evaluated system(s).

RECOMMENDATIONS

When open burning/open detonation (OB/OD) is no longer allowed, cryofracture without explosive recovery is recommended for the demil of M16, M14, M26, and FASCAM family of antipersonnel mines since this process is the next cost effective demil procedure after OB/OD. Prior to the implementation of any of the cryofracture demilitarization alternatives addressed in this report, test programs are recommended to verify the feasibility of the approach, and to establish processing parameters and operating procedures for these items. The test programs will establish actual feed rates and allowable energetic quantities that can be safely processed in an APE 1236 furnace.

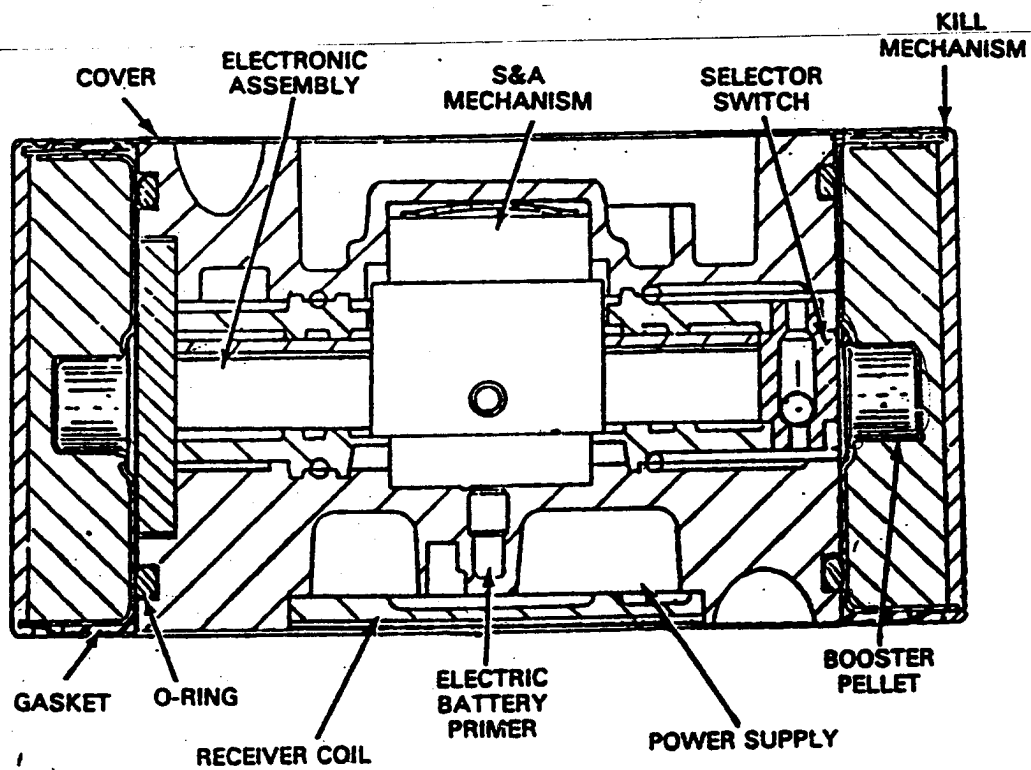
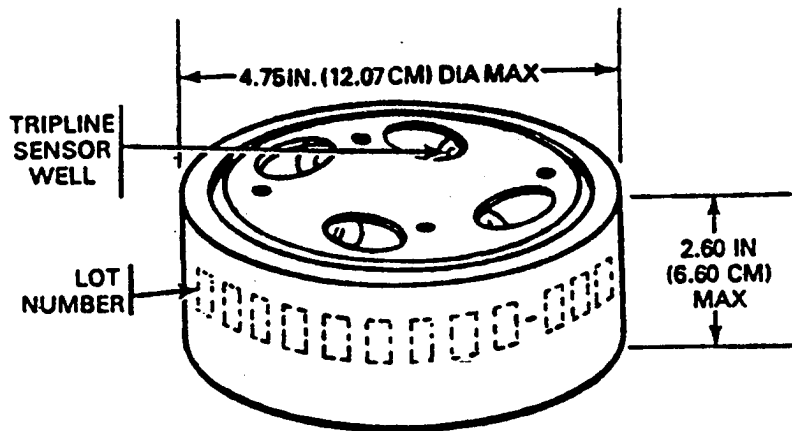
REFERENCES

1. Huntsinger, Jim; Betts, Paul; and Lute, Andrew, "Cryofracture Demilitarization of Munitions (Phase I)," Contractor Report ARAED-CR-96002, General Atomics and the U.S. Army Armament Research, Development and Engineering Center, September 1996.
2. Ayala, David E. and Chamberlain, Spencer, "Test Report Downloading of ICM Submunitions Using the APE 2253 ICM Downloading Machine," Tooele Army Depot, Directorate for Ammunition Equipment, August 1993.
3. TM 43-001-47 Army Equipment Data Sheets – Ammunition Peculiar Equipment, Change 1, 1 May 95.
4. TM 43-0001-36 Army Ammunition Data Sheets for Land mines (FCSB45), Sep. 94.
5. Joint Commanders Group Resource Recovery & Disposition Handbook V01. 1B compiled by JOCG Munitions Demilitarization/Disposal Sub Group, 30 Sep. 96.

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APPENDIX A
M47 HE ANTIPERSONNEL MINE

MINE, ANTIPERSONNEL: HE, M74



ARD 84-1701

Change 6 3-16.1

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Type Classification:

STD-LCC-A (LET 4-11-80, ARDC)

Use:

The ground burst antipersonnel mine M74 can be emplaced only by the ground vehicle mine dispenser M128. This mine may be used in mixed minefields to protect antitank mines against enemy breaching parties.

Description:

The mine is green, is cylindrical in shape, and is fabricated of thick-wall steel tubing which is internally scored for maintaining uniform fragment size. It has an internal safing and arming (S&A) device, an electronic assembly, a power supply, and four tripline assemblies at each end (eight total). The mine is set for a specific (normal) self-destruct time by the manufacturer; however, during operations it can be set for a long self-destruct time, depending on the mission requirement. The mines are shipped and stored in a sealed, desiccated container. The container holds 8 sleeves, each containing 5 mines for a total of 40 mines per container. The containers are palletized, with six containers per pallet.

Functioning:

Partial arming results from the angular velocity obtained as the mine travels through the launcher of the dispenser. A magnetic impulse provided by two transmitter coils located in the launcher muzzle initiates a low-order detonating primer, which activates two reserve batteries. The batteries provide the electrical power for mine functioning. After the mine comes to rest on the ground, a signal from the electronic assembly initiates a pressure cartridge, which causes ejection of the four tripline assemblies. The triplines uncoil from their bobbins until the tripline assemblies impact the ground.

The mine will function in response to any of the following conditions: (1) movement of a tripline, (2) physical disturbance of the mine, (3) expiration of the self-destruct time, or (4) power rundown.

Tabulated Data:**Mine, antipersonnel: HE, M74:**

Painting	Green
Marking	Black
Height (max)	2.60 in. (6.60 cm)
Diameter (max)	4.75 in. (12.07 cm)
Weight	3.10 lb (1.41 kg)
Material	Steel tubing

Operational temperature limits:

Minimum	-40°F (-40°C)
Maximum	+150°F (+66°C)

Explosive weight per mine:

Composition B4	0.90 lb (0.41 kg)
Composition A5	0.22 oz (6.35 g)
PBXN-5:	0.17 oz (4.70 g)

Physical security category

II

DODAC

1345K151

Packing arrangement

5 mines per sleeve

8 sleeves per container

6 containers per pallet

NSN

1345-01-076-3497

**Shipping and storage
container - EMPTY:**

Length	27.30 in. (69.30 cm)
Width	14.10 in. (35.81 cm)
Height	15.20 in. (38.61 cm)
Weight	55.0 lb (25.0 kg)
Cube	3.40 cu ft (0.10 cu m)
NSN	8140-01-089-2763
Part No.	9313655

**Storage tempera-
ture limits:**

Minimum	-60°F (-51°C)
Maximum	+155°F (+63°C)

Sleeve (empty):

Color	Green
Length	24.48 in. (62.18 cm)
Width	5.63 in. (14.30 cm)
Height	3.50 in. (8.89 cm)
Weight	2.12 lb (0.96 kg)

**Shipping and storage
container - LOADED:**

Weight	196.0 lb (88.9 kg)
Storage compati- bility group	D
Quantity-dis- tance class for depot storage	1.1
Quantity-dis- tance class for field storage	E
DOT shipping class	A
DOT markings	EXPLOSIVE MINE
US Coast Guard classification	VII
Shelf life	10 yr

**Pallet (loaded w/
full containers):**

Length	55.50 in. (140.97 cm)
Width	43.00 in. (109.22 cm)
Height	23.13 in. (58.75 cm)
Weight (approx incl dunnage)	1357 lb (616 kg)
Cube	31.93 cu ft (0.90 cu m)

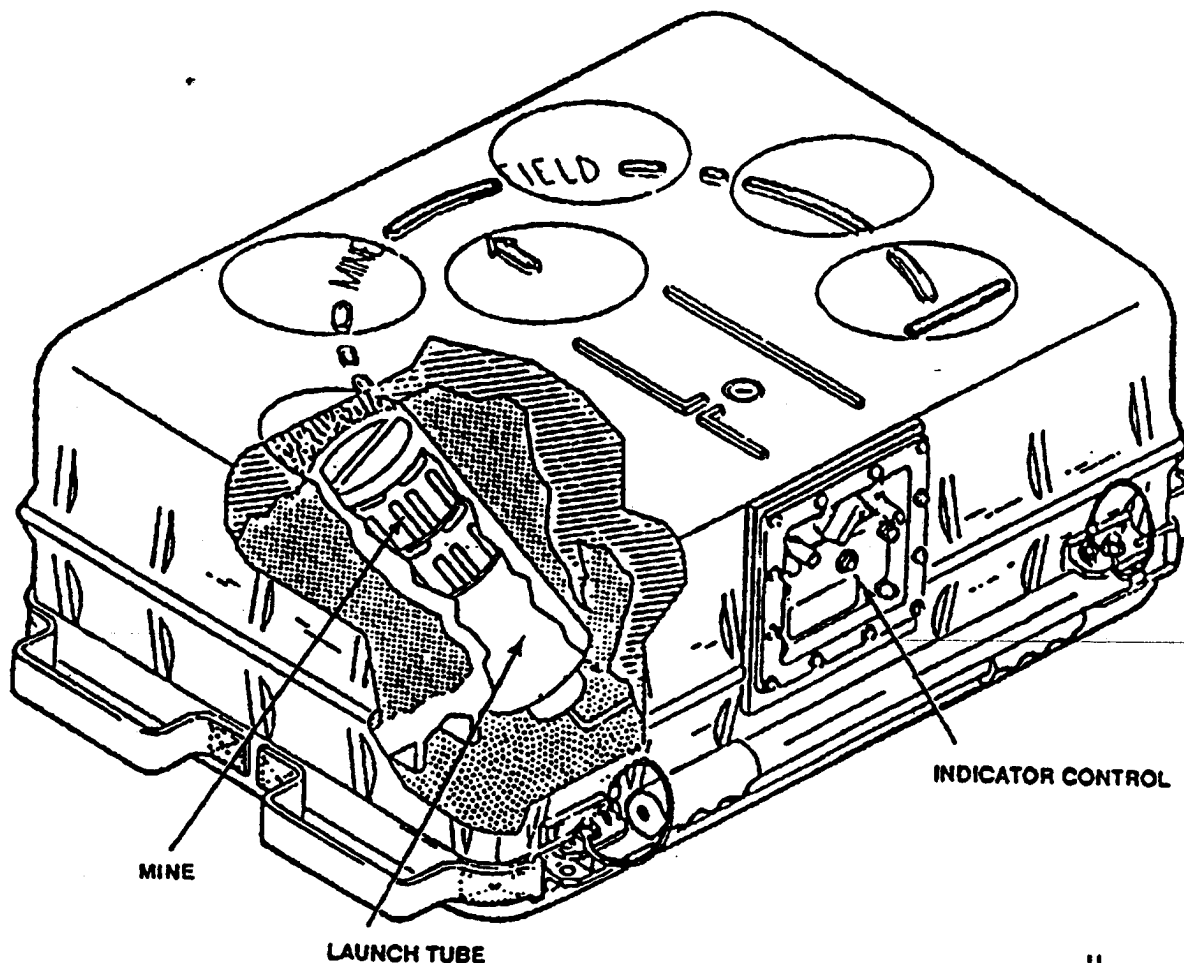
References:

TM 9-1345-210-23&P
TM 9-1095-205-10
SC 1340/98-IL

Note. For classified data pertaining to this item
refer to TM 43-0001-36-1(C).

APPENDIX B
M131 GROUND DISPENSER AND MINES

DISPENSER AND MINES, GROUND: M131



U
AR 4515

Type Classification:

STD-LCC-A (6-20-86)

Use:

The M131 Mine Dispenser is used with the M71 Remote Control Unit (RCU) or Blasting Machine to deploy small antitank and anti-personnel minefields.

Description:

The M131 Mine Dispenser is a man portable, remotely controlled, antipersonnel (AP) and antitank/antivehicle (AT/AV) mine dispensing system. The mines may be deployed on command by a blasting machine hardwired to dispenser or by operating a radio frequency (RF) Remote Control Unit (RCU). The dispenser contains a battery powered Indicator Control (IC) and seven launch tubes. Each tube houses three mines for a total of twenty-

one mines per dispenser (17 AT/AV and 4 AP mines). The IC is powered by a lithium cell battery and contains the electronic package which receives, interprets, and acts on the signals received. The dispenser is designed as a self-contained shipping, storage, and deployment unit that is not reloadable once the mines have been deployed. The mine dispenser, which weighs approximately 160 pounds, is easily emplaced by four persons.

Functioning:

The Indicator Control in the dispenser receives command and control data from the M71 RCU when the magnetic coupling devices of the RCU and dispenser are mated together. If no data is transferred to dispenser, there will be no command and control capability once the mines are deployed. After dispenser is set to arm for 5 minutes, mines can be deployed via the M71 RCU or by a blasting machine hardwire connecting to the Indicator Control.

When the Indicator Control receives the deploy command, it will send signals to the mine Electronic Battery Initiator (EBI) to activate the mine batteries. The Indicator Control then sends control data to mines and activates actuators in dispenser to detonate cartridges to launch mines.

Tabulated Data:

a. Dispenser and Mines, Ground: M131:

Color	Olive drab
Marking	White
Length	81.8 cm
Width	57.6 cm
Height	34.5 cm
Cube	0.137 cu m
Weight (without battery)	68.1 kg (loaded)
Number of tube dispensers	7
Number of mines per tube	3
Total number of mines	21 (4 AP, 17 AT)
Ejection charge	12 gage cartridge (electrically detonated)
Total explosive weight	11.98 kg
Explosives:	
Comp B-4	1.64 kg
RDX Estane	10.03 kg
PBXN-5	258.58 g
Comp A-5	25.12 g
Lead styphnate	21.4 mg
M5 propellant	31.5 g
RD 1333 lead azide	73.0 mg
HMX	336.0 mg
Boron borochromate	170.0 mg
Barium styphnate and KDNBF 50/50 mixture	109.2 mg
Barium nitrate	483.0 mg
Lead azide	378.0 mg
Center lead	4.18 mg
Material:	
Outer	High density rubber filled polyethylene
Inner	Rigid structural foam plastic liner
Tubes	Aluminum
DODAC	1345-K022
UNO serial number	0137
UNO Proper shipping name	Mines
NSN	1345-01-160-8909
Temperature Limits:	
Operation:	
Minimum	-40°C (-40°F)
Maximum	+60°C (+140°F)
Storage:	
Minimum	-57°C (-70°F)
Maximum	+71°C (+160°F)

Power Requirements:

Voltage	11-15 Vdc
Current	7.4 to 8.2 ma

Power source:

Battery, Primary Lithium Organic, BA-5598/U: Rating 10 to 15 volts dc, weight about 1.5 lb

Pallet Configuration:

Pallet size	86.4 cm x 132.1 cm (34 in. x 52 in.)
Pallet weight (including cover and supports)	63.5 kg
Pallet w/6 M131	
Dispensers	472.1 kg
Height - 1 Pallet w/6 dispensers (3 high)	1.22 m (48 in.)
Cube - 1 Pallet w/6 dispensers (3 high)	1.39 cu m (49.1 cu ft)

Shipping and Storage Data:

DOD hazard class	1.1
Storage compatibility group	D
Quantity-distance class	1.1D
DOT shipping class	A
DOT marking	EXPLOSIVE MINES
US Coast Guard Class	X-A
Air Transport Loading/Storage Group (TM 38-250)	6
Shelf life	20 yr

b. Antipersonnel Mine:

Color	Forest green
Height	6.60 cm
Diameter	12.07 cm
Total weight	1.54 kg
Total explosive weight	0.42 kg
Explosives:	
Main charge, Comp B-4	0.41 kg
Booster, Comp A-5 (4 ea)	6.28 g (total)
Explosive lead, PBXN-5 (4 ea)	4.0 g (total)
Main charge leads, PBXN-5 (4 ea)	360.0 mg (total)
M100 Detonator:	
Lead styphnate	0.8 mg
RD 1333 lead azide	14.0 mg
HMX	16.0 mg
Transfer lead, PBXN-5	73.0 mg
MDF assembly, PBXN-5 (2 cords, 4 end caps)	160.0 mg
Cleaning charge M5 propellant (2 ea)	1.5 g (total)
Micro piston actuator-barium styphnate and KDNBF 50/50 mixture	5.2 mg
Battery Primer:	
Barium nitrate	23.0 mg
Lead styphnate	0.8 mg
Lead azide	18.0 mg

c. Antitank Mine:

Color----- Forest green
 Height----- 6.60 cm
 Diameter----- 12.07 cm
 Total weight----- 1.86 kg
 Total explosive weight----- 0.60 kg

Explosives:

Main charge, RDX
 ESTANE----- 0.59 kg
 Booster ring, PBXN-5
 (4 ea)----- 13.6 g
 Main charge leads,
 PBXN-5 (4 ea)----- 360.0 mg (total)
 Center lead----- 246.0 mg
 Delay Detonator:
 Lead styphnate----- 0.08 mg
 RD 1333 lead azide----- 1.0 mg
 Boron borochromate----- 10.0 mg
 HMX----- 16.0 mg

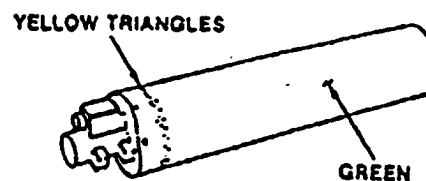
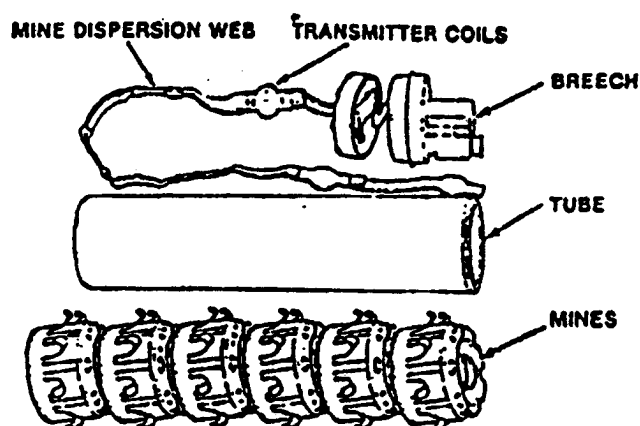
Transfer lead, PBXN-5- 86.0 mg
 MDF assembly,
 PBXN-5----- 84.0 mg
 Cleaning charge M5
 propellant (2 ea)----- 1.5 g (total)
 Micro piston actuator -
 barium styphnate
 and KDNBF 50/50
 mixture----- 5.2 mg
 Battery Primer:
 Barium nitrate----- 23.0 mg
 Lead styphnate----- 0.8 mg
 Lead azide----- 18.0 mg

References:

TM 9-1345-209-10
 TM 9-1345-209-23&P

APPENDIX C
M87 CANISTER MINE

CANISTER, MINE: M87



U
AR 4335

Type Classification:

Standard Jan. 89

Use:

The M87 mine canister is used with the M139 mine dispenser (VOLCANO) to lay a mine field.

Description:

The M87 mine canister is an expendable item consisting of an aluminum tube and breech assembly containing five antitank mines and one antipersonnel mine. Also housed in the canister are six transmitter coils, attached to a dispersion strap, and a propulsion system. The propulsion system consists of a self-contained electrically initiated primer, and a pressure cartridge assembly containing the launching propellant. The canister is painted in green and has one colored band of yellow triangles near the breech.

Functioning:

When an electrical pulse is received, the electric primer initiates the pressure cartridge expelling a mine stack from the canister. The stack consists of five antitank mines and one antipersonnel mine. An interfaced web provides dispersion, self-destruct, and arm signals, set

from the dispenser control unit to the mines.

Tabulated Data:**Canister, Mine: M87:**

Length	24.09 in.
Diameter	5.0 in.
Weight (loaded with 5 AT and 1 AP mines)	13.62 kg (30.0 lb)
Color	Forest Green No. 34079
Marking	Yellow, Black
Contents:	
AT mine	5
AP mine	1
Pressure cartridge	1
Electrical primer	1

Explosives:**AT Mine (Each):**

RDX estane	0.59 kg (1.3 lb)
PBXN-5	13.6 g (0.03 lb)
Lead styphnate	9 mg
RD 1333 lead azide	28 mg
Boron borochromate	10 mg
HMX	32 mg
M5 propellant	1.5 g
Barium styphnate and KDNEF 50/50 mixture	5.2 mg

AP Mine (Each):

Comp B-4	400.00g
Comp A-5	6.28 g

PBXN-5 ----- 4.60 g
 Lead styphnate ----- 0.8 mg
 RD 1333 lead azide ----- 14 mg
 HMX ----- 16 mg
 M5 propellant ----- 1.5 g
 Barium styphnate and
 KDNBF 50/50
 mixture ----- 5.2 mg

Pressure Cartridge:
 Propellant M1 type I ----- 4.8 g
 Propellant, black
 powder ----- 1.0 g
 Lead styphnate ----- 62 mg
 Electric Primer:
 Boron potassium
 perchlorate ----- 10 mg
 Titanium potassium
 perchlorate ----- 25 mg

Mine Canister (Each):
 RDX estane ----- 2.95 kg (6.5 lb)
 PBXN-5 ----- 72.60 g (0.16 lb)
 Comp B-4 ----- 400.00 g
 Comp A-5 ----- 6.28 g
 Lead styphnate ----- 108 mg
 Boron borochromate ----- 50 mg
 HMX ----- 176 mg
 M5 propellant ----- 9 g
 Barium styphnate and
 KDNBF 50/50
 mixture ----- 31 mg
 Propellant M1 type I ----- 4.8 g
 Propellant, black
 powder ----- 1.0 mg
 Boron potassium
 perchlorate ----- 10 mg
 Titanium potassium
 perchlorate ----- 25 mg
 RD 1333 Lead azide ----- 154 mg

Temperature Limits:
 Operational:
 Minimum ----- -37°C (-35°F)
 Maximum ----- +63°C (+145°F)

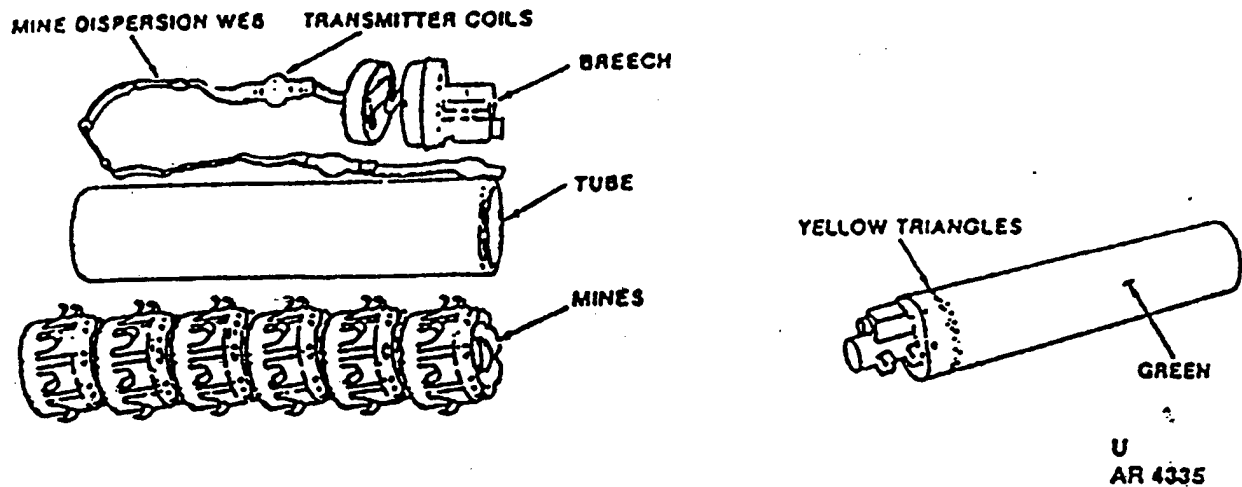
Storage:
 Minimum ----- -53°C (-65°F)
 Maximum ----- +71°C (+160°F)
 Shipping and Storage Container:
 (Metal Tube Type):
 Length ----- 149.86 cm (59.0 in.)
 Diameter ----- 17.27 in. (6.8 in.)
 Weight (empty) ----- 11.34 kg (25.0 lb)
 Weight (packed with 2
 mine canisters) ----- 39.95 kg (88.0 lb)
 Palletization (Metal Pallet):
 Pallet size ----- 71.8 x 149.9 cm
 (28-1/4 x 59.0 in.)
 Pallet weight (empty) ----- 63.5 kg (140. lb)
 Pallet configuration
 (tubes) ----- 4 across x 5 high =
 20 tubes
 Pallet height ----- 99.1 cm (39.0 in.)
 Pallet cube ----- 1.07 cu m
 (37.6 cu ft)
 Pallet weight (loaded) ----- 852.6 kg
 (1,900.0 lb)

Shipping and Storage Data:
 DOD hazard class ----- 1.1
 DOD compatibility
 group ----- D
 DOD hazard class ----- Class A Explosive
 DOT container marking -- EXPLOSIVE
 MINES
 US Coast Guard
 Classification ----- X-A
 Shelf life ----- Indefinite
 DODAC ----- 1345-K045
 NSN ----- 1345-01-233-2029
 UNO serial number ----- UNO137
 UNO Proper shipping
 name ----- Mines

References:

TM 9-1095-208-10
 TM 9-1345-203-12&P
 TM 9-1345-203-34&P

CANISTER, MINE: M87A1

Type Classification:

Standard

Use:

The M87A1 mine canister is used with the M139 mine dispenser (VOLCANO) to lay a mine field.

Description:

The M87A1 mine canister is an expendable item consisting of an aluminum tube and breech assembly containing five antitank mines and one antipersonnel mine. Also, the canister contains six transmitter coils, attached to a dispersion strap, and a propulsion system. The propulsion system consists of a self-contained electrically initiated primer, and a pressure cartridge assembly containing the launching propellant. The canister is painted in green and has one colored bank of yellow triangles near the breech. The M87A1 is an improved version of the M87 mine canister.

Functioning:

When an electrical pulse is received, the electric primer initiates the pressure cartridge expelling a mine stack from the canister. The stack consists of five antitank mines and one anti-

personnel mine. An interfaced web provides dispersion, self-destruct, and arm signals, set from the dispenser control unit to the mines.

Tabulated Data:

Canister, Mine: M87A1:

Length	24.09 in.
Diameter	5.0 in.
Weight (loaded with 5 AT and 1 AP mines)	13.62 kg (30.0 lb)
Color	Forest Green No. 34079
Marking	Yellow, Black
Contents:	
AT mine	5
AP mine	1
Pressure cartridge	1
Electrical primer	1

Explosives:

AT Mine (Each):

RDX estane	0.59 kg (1.3 lb)
PBXN-5	13.6 g (0.03 lb)
Lead styphnate	9 mg
RD 1333 lead azide	28 mg
Boron borochromate	10 mg
HMX	32 mg
M5 propellant	1.5 g
Barium styphnate and KDNBF 50/50 mixture	5.2 mg

AP Mine (Each):

Comp B-4----- 400.00 g
 Comp A-5----- 6.28 g
 PBXN-5----- 4.60 g
 Lead styphnate----- 0.8 mg
 RD 1333 lead azide----- 14 mg
 HMX----- 16 mg
 M5 propellant----- 1.5 g
 Barium styphnate and
 KDNBF 50/50
 mixture----- 5.2 mg

Pressure Cartridge:

Propellant M1 type I----- 4.8 g
 Propellant, black
 powder----- 1.0 g
 Lead styphnate----- 62 mg
Electric Primer:
 Boron potassium
 perchlorate----- 10 mg
 Titanium potassium
 perchlorate----- 25 mg

Mine Canister (Each):

RDX estane----- 2.95 kg (6.5 lb)
 PBXN-5----- 72.60 g (0.16 lb)
 Comp B-4----- 400.00 g
 Comp A-5----- 6.28 g
 Lead styphnate----- 6.28 g
 Boron borochromate----- 50 mg
 HMX----- 176 mg
 M5 propellant----- 9 kg
 Barium styphnate and
 KDNBF 50/50
 mixture----- 31 mg
 Propellant M1 type I----- 4.8 g
 Propellant, black
 powder----- 1.0 mg
 Boron potassium
 perchlorate----- 10 mg
 Titanium potassium
 perchlorate----- 25 mg
 RD 1333 lead azide----- 154 mg

Temperature Limits:

Operational:
 Minimum----- -37°C (-35°F)
 Maximum----- +63°C (+145°F)
Storage:
 Minimum----- -53°C (-65°F)
 Maximum----- +71°C (+160°F)

Shipping and Storage Container:

(Metal Tube Type):
 Length----- 149.86 cm (59.0 in.)
 Diameter----- 17.27 in. (6.8 in.)
 Weight (empty)----- 11.34 kg (25.0 lb)
 Weight (packed with 2
 mine canisters)----- 39.95 kg (88.0 lb)
Palletization (Metal Pallet):
 Pallet size----- 71.8 x 149.9 cm
 (28-1/4 x 59.0 in.)
 Pallet weight (empty)----- 63.5 kg (140. lb)
 Pallet configuration
 (tubes)----- 4 across x 5 high =
 20 tubes
 Pallet height----- 99.1 cm (39.0 in.)
 Pallet cube----- 1.07 cu meter
 (37.6 cu ft)
 Pallet weight (loaded)----- 852.6 kg
 (1,900.0 lb)

Shipping and Storage Data:

DOD hazard class----- 1.1
 DOD compatibility
 group----- D
 DOD hazard class----- Class A Explosive
 DOT container marking----- EXPOSIVE MINES
 US Coast Guard
 Classification----- X-A
 Shelf life----- Indefinite
 DODAC----- 1345-K042
 NSN----- 1345-01-384-3617

References:

TM 9-1095-208-10-1
 TM 9-1095-208-23-1&P
 TM 9-1345-203-12&P

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